

# Contents

<b>Abstract</b>	<b>ix</b>
<b>Deutsche Kurzfassung (German Extended Abstract)</b>	<b>x</b>
<b>Nomenclature, Abbreviations and Symbols</b>	<b>xix</b>
<b>1 Thesis Overview</b>	<b>1</b>
1.1 Service Diagnosis . . . . .	1
1.2 Contributions of This Thesis: Systematic Test Design Methods . . . . .	2
1.3 Thesis' Outline . . . . .	3
<b>2 Introduction to Consistency-Based Service Diagnosis</b>	<b>5</b>
2.1 Introduction to Service Diagnosis . . . . .	5
2.2 Fault-Hypothesis Rejection . . . . .	7
2.3 Sequential Refinement of the Diagnostic Result . . . . .	9
2.4 Consistency-Based Diagnosis . . . . .	12
2.5 Automatic Testing as Active Diagnosis . . . . .	14
2.6 Literature Survey . . . . .	15
2.6.1 Service Diagnosis . . . . .	16
2.6.2 Active Diagnosis . . . . .	16
2.6.3 Structural Analysis for Diagnosis . . . . .	19
2.6.4 Structural Approaches to Active Diagnosis . . . . .	21
2.7 Assumptions and Problem Statement for This Thesis . . . . .	23
2.8 Summary . . . . .	24
<b>3 Modeling Framework</b>	<b>25</b>
3.1 System-Behavior Representation by Constraint Sets . . . . .	25
3.2 Behavioral Description of Dynamical Systems . . . . .	26
3.3 Analytical Model of Dynamical Systems . . . . .	28
3.3.1 System Variables . . . . .	28
3.3.2 Constraint Types . . . . .	29
3.3.3 Qualitative Fault Models . . . . .	30
3.3.4 Elimination-Minimal Representation . . . . .	32

3.4	Running Example: Plant A	32
3.5	Summary	33
<b>4</b>	<b>Diagnosability Analysis by Means of Directed Structure Graphs</b>	<b>35</b>
4.1	Chapter Overview	35
4.2	Consistency Tests with Global Residual Generators	37
4.3	I/O-Detectability	42
4.4	I/O-Discriminability	51
4.5	Global Structural Model of Dynamical Systems	57
4.5.1	Global Structure Graph	57
4.5.2	Canonical Decomposition of the Structure Graph	63
4.5.3	Global Structural Properties of Constraint Sets	64
4.6	Directed Global Structure Graph	67
4.6.1	Uniqueness of Constraints Solved for a Variable (Causality)	67
4.6.2	Directed Global Structure Graph	68
4.7	Determining Global Residual Generators	70
4.8	Global Structural Detectability and Discriminability	74
4.9	Limits of Global Structural Analysis	77
4.10	Summary	81
<b>5</b>	<b>Analysis of Local Structure Graphs</b>	<b>83</b>
5.1	Locality of Couplings and its Consequence for Diagnosis	83
5.2	Operating Region	84
5.3	Additional Structural Properties Valid in Specific Operating Regions	87
5.4	Directed Local Structure Graph	92
5.5	Local Structural Properties of Constraint Sets	97
5.6	Local Residual Generator Design	107
5.7	Summary	112
<b>6</b>	<b>Design of Diagnostic Tests</b>	<b>113</b>
6.1	Extension to a Method for the Design of Automatic Tests	113
6.2	Automatic Test	115
6.3	Diagnostic Unit	115
6.4	Operating Region Detection	117
6.5	Decision Logic Design	122
6.5.1	Test Sensitivity	122
6.5.2	Hypothesis Rejection	125
6.6	Input Generator Design	126
6.7	Defining All Tests	129
6.8	Special Case: Fault Hiding	133
6.9	Summary	135

<b>7</b>	<b>Application to a Throttle Valve</b>	<b>137</b>
7.1	System Description . . . . .	137
7.2	Analytical System Model . . . . .	138
7.3	Global Structural Analysis . . . . .	141
7.4	Test Generation . . . . .	142
7.5	Simulation Study . . . . .	145
7.6	Summary . . . . .	148
<b>8</b>	<b>Conclusions and Outlook</b>	<b>151</b>
	<b>Bibliography</b>	<b>157</b>